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Bananas Grown in Salt Affected Soil Impairs Fruit Development in Susceptible Cultivars

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ABSTRACT

Problem soils primarily affect plant growth through root either directly or indirectly with combination of osmotic and ionic stress. Banana is sensitive to salinity effect. Banana fruit development studies were undertaken in four banana genotypes , Saba (ABB) , Ney Poovan (AB) , Nendran (AAB) and Robusta (AAA) in salt affected soil (pH 8.1 and EC $_{1:2.5=}$ 3.1). The study revealed that, the tolerant genotype Saba, could maintain the fruit development. The conversion of sugars into starch was not affected in the fruit. The salt susceptible banana cultivars Nendran and Robusta could not produce normal fruit development as it suffered from poor conversion of sugars into starch in the pulp. The Saba genotype seems to be effectively excluding the sodium salt at root or cellular level to maintain physiological functions of the plant.

Key words : Banana cultivars, Fruit growth, Ney Poovan, Robusta, Saba, Salt.

Salt affected soils limits agriculture production, because of toxic levels of salts or deficiency of plant essential nutrients. These soils have low productivity and have great potential for agriculture production if managed effectively. Problem soils primarily affect plant growth through root either directly or indirectly with combination of osmotic and ionic stress. Banana is considered as sensitive to salinity (Israeli *et al*., 1986) and he reported for acuminata clones. Common banana cultivars differ in their genome (A and B) are derived from two different species, i.e. acuminata and balbisiana. Triploids bananas are commonly cultivated by farmers. The banana genetic makeup with B genome considered to be hardy to abiotic stresses (Gowen 1995). At NRCB a few cooing genotypes (Saba, and Monthan) were found to be field tolerant to salt stress and most of the dessert bananas are susceptible to salt stress. The salt stress injuries initially expressed as leaf margin necrosis and later progressed towards centre part of leaf. This symptom appears in acropetal manner leaves. Salt effect manifested in plants as relatively smaller stem thickness and prolonged duration to flowering, sometime, for more than 2-3 months. Susceptible cultivars failed to develop normal finger (fruit) size and the level of marketable bunch. Negligible literatures are available on fruit development in banana under salt affected condition. In this context banana fruit growth, sugar and starch accumulation in susceptible and tolerant cultivars were studied in the salt affected field.

MATERIAL AND METHODS

Field experiment was conducted out at National Research Center for Banana farm located in Trichy with 11.50^{o} N latitude and 74.50^{o}E longitude, 90 MSL. Four banana cultivars, *Musa* AAA (Cavendish subgroup) 'Robusta', *Musa* AAB (Plantain subgroup) 'Nendran', *Musa* AB 'Ney Poovan' (Safed Velchi), and *Musa* ABB Saba (Cooking banana), were planted with sword suckers of uniform size in 0.5 acre of field during 2007-08 and 2008-09. The experiment was laid out with simple randomized complete block design with five replications. Each replication had 20 plants for each genotype. Soil samples were taken with standard procedure to analyse EC and pH. The pH and EC$_{1:2.5}$of the soil was 8.1 and 3.1 respectively. Recommended cultural practices were followed for growing plants in the field. Plants flowered in same or next day were tagged for each variety. Two batches (different time) of tagging were done for each variety for repeating physical and biochemical analyses. Three plants were tagged for each replication in each batch. At 30 days interval after full bunch opening (7 days after flowering) fruits were harvested from the 2nd hand

Table 1. Fruit physical parameters variation in different banana cultivars grown in salt affected soil.

Banana cultivars	Least Square Mean of Fruit length (cm)	Least Square Mean of Fruit circumference (cm)	Least Square Mean of Fruit Volume (cm^3)	Least Square Mean of Fruit density	Least Square Mean of Fruit pulp's fresh weight (g)	Least Square Mean of Fruit peel's fresh weight (g)
Saba	14.08 A	12.25 A	104.27 A	0.72 C	47.377 A	33.09 A
Ney Poovan	8.83 C	8.01 B	32.33 B	0.97 B	21.69 B	8.25 C
Nendran	11.42 B	7.06 C	19.33 C	0.95 B	10.68 C	10.61 B
Robusta	9.13 C	5.71 C	8.55 D	1.15 A	3.12 D	8.73 C

Means grouped by common letters in a column are not significant at LSD at 5%

Table 2. Fruit physical parameters, after flowering, of banana grown in salt affected soil.

DAF	Least Square Mean of Fruit length (cm)	Least Square Mean of Fruit circumference (cm)	Least Square Mean of Fruit Volume (cm^3)	Least Square Mean of Fruit density	Least Square Mean of Fruit pulp's fresh weight (g)	Least Square Mean of Fruit peel's fresh weight (g)
7	8.57 C	6.45 C	17.58 B	0.88 C	3.37 D	8.87 D
30	10.08 B	7.24 B	24.80 B	0.85 BC	7.19 C	14.12 C
60	11.58 A	8.95 A	52.02 A	0.98 AB	27.56 B	16.43 B
90	11.98 A	9.25 A	55.41 A	101 AB	32.14 A	17.75 AB
110	12.13 A	9.40 A	55.78 A	1.01 A	33.13 A	18.69 A

Means grouped by common letters in a column are not significant at LSD at 5%
DAF = Days after flowering

from morphologically lower side of the bunch and brought to laboratory immediately for physical and biochemical analyses. The Physical Parameters like fruit length, fruit circumference, fruit weight, volume, densities were measured as per Dadzie and Orchand (1997). Fifteen green fruits for each replication were separated into pulp and peel with clean scissor and cut into *ca.* 5 mm^2 size. Five gram of pooled cut size pulp and peel were plunged into 95% hot ethanol for measuring reducing and total sugars. For starch analysis, as soon as green fruits were peeled off, pulps and peel were sliced and completely immersed into 2% ascorbic acid solution for ten minutes to prevent oxidative browning. These treated sliced samples were dried in hot air oven at 55 ^{o}C for 48 hrs, milled into powder and sieved with 0.2mm mesh and stored at 25 ^{o}C in air tight plastic containers for further analysis. The biochemical parameters like total sugars and reducing sugars (Mc Creedy *et al.,* 1950, Nelson 1944 and Somogyi, 1952) and starch were determined (Mc Creedy et al 1952 and Scott and Melvin 1953) from these samples. The data were analysed using SAS 9.2 version with PROC GLM method.

RESULTS AND DISCUSSION

Salts in the soil water may inhibit plant growth for two reasons. First, the presence of salt in the soil solution reduces the ability of the plant to

Table 3. Banana genotype differences in sugars and starch content in fruit pulp during development.

Banana cultivars	Least Square Mean of pulp's total sugars (mg/g dry weight)	Least Square Mean of pulp's reducing sugars (mg/g) dry weight)	Least Square Mean of pulp's non -reducing sugars (mg/g dry weight)	Least Square Mean of pulp's starch (mg/g dry weight)
Saba	0.114 D	0.082 C	0.032 C	22.17 A
Ney Poovan	0.495 A	0.329 A	0.166 A	20.58 B
Nendran	0.304 B	0.187 B	0.117 B	5.45 C
Robusta	0.172 C	0.048 D	0.124 B	3.85 D

Means grouped by common letters in a column are not significant at LSD at 5%

Table 4. Changes in sugars and starch content in fruit pulp during development at different days of interval in banana grown in salt affected soil.

DAF	Least Square Mean of pulp's total sugars (mg/g dry weight)	Least Square Mean of pulp's reducing sugars (mg/g) dry weight)	Least Square Mean of pulp's non -reducing sugars (mg/g dry weight)	Least Square Mean of pulp's starch (mg/g dry weight)
7	0.094 E	0.054 E	0.040 D	3.02 E
30	0.230 D	0.137 C	0.092 C	4.87 D
60	0.405 A	0.283 A	0.122 B	12.12 C
90	0.334 B	0.236 B	0.097 C	21.83 B
110	0.293 C	0.098 D	0.195 A	23.23 A

Means grouped by common letters in a column are not significant at LSD at 5%
DAF = Days after flowering

take up water, and this leads to reductions in the growth rate. This is referred to as the osmotic or water-deficit effect of salinity. Second, if excessive amounts of salt enter the plant in the transpiration stream there will be injury to cells in the transpiring leaves and this may cause further reductions in growth. This is called the salt-specific or ion-excess effect of salinity (Greenway and Munns 1980). Banana is categorised as sensitive (Israeli *et al.,*1986). Banana fruit weight and size (length and diameter) are important commercial criteria for marketing bananas, as they influence the price. The present investigation revealed that banana genotypes fruit physical parameters like fruit length, circumference, fruit pulp and peel weight, volume and density were affected by salts (Table1).Among all the genotypes Saba recorded superior in all physical parameters like length (14.08 cm) , circumference (12.25 cm), volume (104.27 cm^3), pulp weight (47.38 g) , peel weight (33.09 g) and fruit density (0.72). The lower fruit density expresses the active status of fruit tissues. Among all the cultivars, Robusta fruit recorded higher fruit density (1.15), where the physiological functions are seems to be inactive status. Nendran and Robusta fruits lengths are generally in the range of 20 -25 cm under normal soil conditions. Here their fruit lengths were severely restricted. Next to Saba,

Table 5. Banana genotype differences in sugars and starch content in fruit peel during development.

Banana cultivars	Least Square Mean of pulp's total sugars (mg/g dry weight)	Least Square Mean of pulp's reducing sugars (mg/g) dry weight)	Least Square Mean of pulp's non -reducing sugars (mg/g dry weight)	Least Square Mean of pulp's starch (mg/g dry weight)
Saba	0.074 D	0.058 D	0.015 C	11.49 A
Ney Poovan	0.519 C	0.398 C	0.120 B	5.13 B
Nendran	0.674 B	0.560 B	0.115 B	1.97 C
Robusta	1.111 A	0.744 A	0.367 A	1.13 D

Means grouped by common letters in a column are not significant at LSD at 5%

Table 6. Changes in sugars and starch content in fruit peel during development at different days of interval in banana grown in salt affected soil.

DAF	Least Square Mean of pulp's total sugars (mg/g dry weight)	Least Square Mean of pulp's reducing sugars (mg/g) dry weight)	Least Square Mean of pulp's non -reducing sugars (mg/g dry weight)	Least Square Mean of pulp's starch (mg/g dry weight)
7	0.939 A	0.716 A	0.222 A	1.54 E
30	0.778 B	0.553 B	0.224 A	2.34 D
60	0.542 C	0.424 C	0.118 B	5.86 C
90	0.394 D	0.286 D	0.108 B	7.31 B
110	0.322 E	0.222 E	0.101 B	7.61 A

Means grouped by common letters in a column are not significant at LSD at 5%
DAF = Days after flowering

Ney Poovan recorded better physical parameters (Table1).

When we analyse the growth of physical parameters like fruit length, circumference, volume and fruit density at different days of interval, after full bunch opening, they reached its maxima by 60 days after flowering under salt affected soil condition (Table 2) Generally all these physical parameters reaches its maxima or plateau by 90 - 100 days after flowering. The data clearly suggest that, salt impairs fruit physical parameters.

Banana fruits are made of starch. During fruit development sugars are imported from sources to developing fruit (sink) and converted and stores as starch. In the present investigation non-structural carbohydrates (sugars and starch) were analysed in pulp (Table 3 and 4) and peel (Table 5 and 6) of banana fruit. Among the tested genotypes Saba recorded lower total sugars (0.114 mg /g) in pulp than all other genotypes (Table 3). This shows that, this cultivar could efficiently convert the available assimilates into starch (22.17 m/g fr.wt.). The Nendran and Robusta could accumulate more sugars than other genotypes as it shows the poor efficiency in conversion of sugars into starch (5.45 and 3.85mg / g fr.wt. respectively). In Ney Poovan, though sugars were accumulated, it could utilise and efficiently convert them into starch (20.58 mg

/g fr.wt.) Table -3). Generally matured freshly harvested green banana fruit pulp contain starch in the range of 70 -80% on dry weight basis (Ravi and Mustaffa2012) and 26- 29% in fresh weight basis.

When we analysed the sugars at different interval of all the varieties, the sugars utilised in the early stages pulp of growth and it accumulates in the pulp as growth stage advanced. The sugars (total and reducing) reach its maxima (0.405 and 0.283 mg /g fr.wt.) by 60 days after flowering (Table-4). The non reducing sugars reached its maxima (0.195 mg/ g fr.wt) after 110 days after flowering. The sugars and starch were analysed in banana fruit peel. Here the pattern of sugars and starch accumulation follows the similar pattern as far as banana cultivars are concerned. Saba genotype accumulated lesser sugar content (0.074 mg/ g) than other genotypes. Similarly starch content also higher in Saba (11.49 mg/g) (Table -5). The pattern of sugar accumulation in the peel varied compared to pulp. The peel accumulated more (0.939 mg / g) at 7 days after flowering and gradually reduced to 0.322 mg / g at 110 days after flowering (Table 6). Here the utilization of sugars for fruit development is clearly expressed.

The present experiment came out with certain vital findings of banana grown under salt affected soil. The salt tolerant banana genotype, Saba, could maintain the banana fruit growth by effective utilization of sugars and convert them into starch. Salt sensitivity of some nonhalophytes may be due to insufficient uptake of electrolytes for pressure or volume maintenance, particularly in the expanding tissues (Greenway and Munns 1980). The tolerant Saba genotype seems to have mechanism at root or cellular level to exclude salt without impairing normal physiological functions. The mechanism of salt tolerance in Saba is worth studying for better management and improvement programme in banana.

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